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ABSTRACT

This document contains the following papers on science from the SITE (Society for Information Technology & Teacher Education) 2002 conference: (1) "Color & Light: Design and Evaluation of a Multimedia-Case for Elementary Teacher-Education" (Peter Blijleven and Ellen van den Berg); (2) "Standards-Based Design of Technology-Integrated Science Courses" (Melissa S. Dieckmann and others); (3) "On-Line Microscopes & Inquiry-Based Science Instruction: Improving Technology in Teacher Education" (Thomas Frizelle and Constance Hargrave); (4) "Teaching Science to Elementary Teachers: Exploring 'Our Physical World' through Science and Technology" (C. Richard Hartshorne and F. Eugene Dunnam); (5) "Relationships between the Use of Web Resources and Student Interests in Science: Support for Technology Integration Decision-Making" (Tiffany A. Koszalka); (6) "The Regents Scholars Program--Creating a Statewide Collaboration To Enhance Mathematics and Science Education" (Marietta Langlois and Sheryl Hansen); (7) "Negotiative Concept Mapping" (Gregory R. MacKinnon); (8) "Using the Spreadsheets To Enhance the Learning of Science at Foundation Year Chemistry" (Stimela Simon Mathabatha); (9) "Anchoring Instruction in a Web-Based Adventure Game: How Does It Work?" (Leslie M. Miller and others); (10) "Math and Science Education Using Spreadsheets and Modeling" (Simon Mochon); (11) "Science and Mathematics Teachers Perceptions' of Graphing Calculators and Change" (Scott W. Slough and Gregory E. Chamblee); (12) "Integrating Remote Scientific Instrumentation in the Curriculum To Support Inquiry: Case Studies in K-12 and Teacher Education" (Umesh Thakkar and others); and (13) "Measuring and Identifying Trees with the Help of Technology" (Marvin N. Tolman and others). Several brief summaries of conference presentations are also included. Most papers contain references. (MES)

Science (SITE 2002 Section)

Linda Easley Roach. Ed.

SECTION EDITOR:

Linda Easley Roach, Northwestern State University of Louisiana

The Science Section of SITE 2002 offers a variety of presentations in several formats including full papers, short papers, an interactive session, a workshop, a demonstration, and video presentation.

Among full papers presented, hear results from Tiffany Koszalka's study investigating the relationships among the use of different types of resources during instructional experiences in middle school science and career interests. Tom Frizzell will provide in formation about using the scanning electron microscope to augment content and pedagogy preparation of preservice teachers. Umesh Thakkar also utilizes scientific instrumentation technology to facilitate learning. Hear how teachers and teacher educators are integrating Bugscope into their lessons. Another paper, describing a collaboration among university faculty, local teachers, and students, describes the Riverlink project and its use of data collection and analysis to facilitate science learning.

Short papers include a description of a course, "Our Physical World: Science for Elementary Teachers" by Charles Hartshorne from the University of Florida, and how is uses technology-enhanced learning environments to support science instruction to elementary teachers. Also hear Marietta Langlois descript a program through which inservice teachers can get professional development that combines mathematics and science content with inquiry based pedagogy.

Come to an interactive session to see how Bill Macintyre uses *Starry Night*, a computer planetarium program. He will demonstrate how 2 or 3 students can work co-operatively on a single computer to achieve mastery of the spatial aspects of astronomy.

In Lisa Bienvenue's workshop, you will learn to use several freely available web-based science and mathematics visualization and modeling tools to help you teach Biology, Earth Science, Mathematics, Chemistry, and Environmental Science.

From Patricia Donohue's session, you will take home our easy step-by-step guide called Natureshift Exploration Model. You will learn how to apply the NS Exploration Model to your classroom, to build learning experiences that will help your students pick an individual path to their own learning.

See A Gathering of BUGS- Bringing Up Girls in Science. Mark Mortensen will present a videotape showing how his 4^{th} and 5^{th} grade girls learn science in an after-school program at the University of North Texas.

Linda Easley Roach teaches science methods to senior preservice teachers at Northwestern State University in Louisiana. She is also the University Contact Person for all Alternate Paths to Certification for NSU.

SCIENCE

Incorporating Technology in Early Childhood Science Activities

Michael Joseph Bell, West Chester University, US

Science activities for young children should focus on the world around them. Life and earth science, properties of objects, physical science and biological science should be highlighted, for young children to understand scientific concepts in terms of their daily lives. Incorporating technology in early childhood science requires teachers to (1) integrate technology through methods that comp liment science curricula and uphold the principles of developmental and authentic early education, (2) use materials and equipment that augment and support young children's perceptions of their world for the purposes of gaining accurate information, and (3) support child-centered methods of organizing information and understandings.

This paper will focus on inquiry-based methods of incorporating technology into early childhood science activities. Considerations for developmentally appropriate and authentic science experiences for young children will be discussed, as well as the effective use of technology to broaden each child's skill development in gathering and organizing information about their world. Early childhood educators should view their role in science activities from the perspectives of facilitator with the goal of expanding young children's skill development through child-centered science activities that promote autonomy, independent decision-making, and scientific curiosity.

Color & Light: Design and Evaluation of a multimedia-case for elementary Teacher-Education

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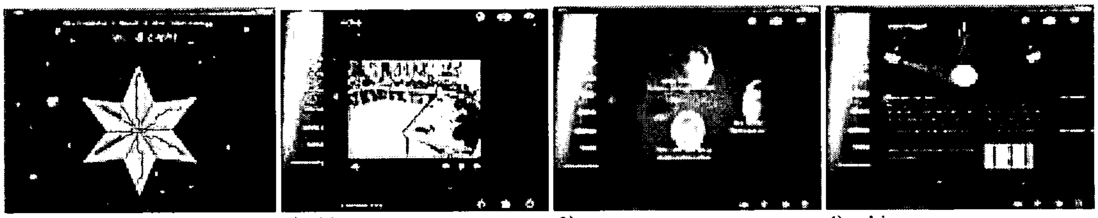


1) introduction-page 2) video-page 3) comments-page 4) subject matter-page

Introduction

This paper presents the design and evaluation of the MUST multimedia-case 'Color & Light'. This case has been developed within the framework of the MUST-project (MUltimedia in Science & Technology). The MUST-project is a joint venture on behalf of three Teacher Education Colleges, the National Institute for Curriculum Development and the University of Twente in the Netherlands. The MUST-team aims at developing and researching multimedia-cases and support tools for the professional development of preservice-teachers in Dutch elementary science education (Van den Berg, Jansen, & Blijleven, 2000).

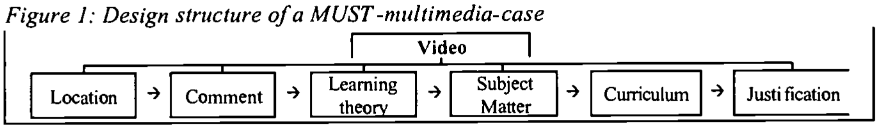
Cases, Case-based Instruction and Multimedia-cases

A case is a realistic description of subsequent activities carried out by professionals. Multimedia applications add the power of computer technology to approaches of case-based instruction, because multimedia can stimulate more than one sense at a time and in doing so, may get and hold more attention (Jonassen & Reeves, 1996, p. 703).

Design of the MUST Multimedia-case 'Color & Light'

'Color & Light' is developed on the basis of an 'evolutionary prototyping' approach. This approach combines input from theory and practice through the cyclic process of analysis, design, development and formative evaluation of prototypes (Smith, 1991). The structure (see Figure 1) of the first MUST-case 'Liquids in Testtubes' is used as a framework for the development of each MUST-case. The subsequent components of each case were designed on the basis of curriculum deliberate processes in the MUST-team. Formative evaluations are an integral of the MUST design approach (developmemtal research: Van den Akker, 1999).

Figure 1: Design structure of a MUST-multimedia-case



The interface of 'Color and Light'

The interface-structure of every MUST-case is the same. Each page can be divided into two main parts, namely: (1) the *navigation-part*, which contains buttons (hyperlinks) for the navigation through the case and (2) the *main-part*, wherein the information to be studied is presented. The navigation part has also another function. Its color and background-illustration 'tells' the user what the subject matter of the involved multimedia-case is about. The navigation-part of 'Color & Light' consists of a colorful bar with an image of a rainbow, representing the topics 'color' and 'light'. Next, the different components of a MUST are presented.

Video

The core-component of a MUST-case consists of non-scripted edited videos of an elementary science lessons, representing both a realistic and relevant context for preservice-teachers. The clips are edited in a way, that provides the opportunity to analyze the presented lesson(s) critically (cf. Merseth, 1996). The video-page of 'Color & Light' consists of three videos. In the first video this series of lessons is introduced by means of an narrative about two children buying new clothes and a class discussion about this narrative. This lesson is an example of how a teacher can activate pupils' concepts (about 'color' and 'light'). The second and third lesson are hands-on experiments with different colors of paint and felt-tipped pens. Aim of these two lessons is to give pupils the opportunity to check and if necessary adjust their concepts about 'color' and 'light' phenomena.

Location

The location-page of a MUST -case gives the student background information about the school, the class and the video-teacher. Aim of this component is to give students the opportunity to interpret and judge the teacher's actions and to compare the 'video-school' with their own student-teaching schools. The class-section consists of background information about the pupils. This section starts with a clickable photo of the class. By clicking on one of the pupils, the user gets detailed information about the selected pupil (e.g. who is this pupil, what does this pupil think of: the school, the series of 'color' and 'light' lessons and science in general). The class-section contains also scans of the assignments, pupils carried out during the hands-on experiments. Preservice-teachers can view these assignments to check what the pupils learned from the series of lessons.

Comments

This component includes comments on the video-lessons by the video-teacher, experts and preservice-teachers. Aim of these comments is to let students experience that certain lessons, in this case a lesson about 'Color & Light, can be considered from different perspectives. These different perspectives add, according to Shulman (1992 p.12), complexity and richness to a case that gloss rather than simplify or trivialize a case.

Subject matter

The subject matter-page is meant for preservice-teachers, who are uncertain about their own subject matter knowledge. This page offer preservice-teachers the possibility to refresh or increase their subject matter knowledge. In the 'Color & Light' production, the subject matter is presented by means of small animations and simulations of 'mixing colors', 'refraction of light' and the working of a prism. A major advantage of using animations and simulations is that they let students experience 'color' and 'light' phenomena in an active way.

Other Hyperlinks

On the curriculum-page, the user can find information about how the case is related to the content areas for elementary science and to the national standards in the Netherlands. The 'learning theoretical background' page consists of information about different ways to open pupil's concepts about 'color' and 'light'. Aim of this component is to make students aware, that there are more ways to open pupil's concepts, than the method presented in the video-lessons. A brief justification of the rationale and the decisions made during the design and development of the multimedia-case are presented on the justification-page of the cd-rom (For a more elaborate description of the design of a MUST multimedia-case, see Van den Berg & Visscher-Voerman, 2000).

Formative evaluations of the MUST Multimedia-case 'Color & Light'

In the forthcoming months, several formative evaluations will be conducted. First, the "technical usability" is investigated by means of expert appraisal and a test with preservice-teachers. More important, are two try-outs in which the effectiveness of the case is subject of study. The first try-out is focused on the actual learning processes of preservice teachers working with the case. The second try-out aims at gaining insight in the transfer effect of the cases and therefore concentrates on the realtionship between the case and student teaching.

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Standards-Based Design of Technology-Integrated Science Courses

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Abstract: National and international assessments of K-12 science literacy indicate that most U.S. students have inadequate knowledge of science, and statewide exams from Kentucky confirm this trend for the Commonwealth. This disturbing trend has precipitated the design of a series of four inquiry-based science courses geared toward K-8 pre-service teachers. These courses are unique compared to other general education science courses at EKU in several respects: (1) they are designed using Kentucky Department of Education's guidelines for Standards-Based Units of Study; (2) they use inquiry-based learning following Newton's Rules of Reasoning in Philosophy; (3) they use collaborative teams to create a group learning environment; (4) they introduce technology as an integral tool to enhance science learning; and (5) pedagogy issues are integral to the course structure. Analysis of student content knowledge and attitude toward science demonstrates that these courses increase student learning in science and improve student attitude about teaching science.

Introduction

Results from the Third International Mathematics and Science Study (TIMSS) administered in 1996 (NCES, 1999) and 1999 (Martin et. al., 2000) demonstrate that U.S. students continue to perform poorly in science knowledge and skills compared to their counterparts in other developed nations. This trend is mirrored in science performance data from Kentucky, which shows that only 5% of elementary students in 1999-2000 were considered proficient in science, while only 1% of middle school students obtained science proficiency during the same academic year (Kentucky Department of Education (KDE), 2000). Results from the 2000 National Assessment of Educational Progress indicate that a statistical correlation exists between science performance and science teacher preparation (NCES, 2002). Preliminary statistical analysis of K-12 student performance in Kentucky shows a similar correlation between the science course requirements for K-12 teacher education programs and performance of students taught by these teacher education graduates. One solution to this problem is to ensure that teacher education programs include science requirements that demonstrate best teaching practices in the sciences and that contain the core content that will be taught in the K-12 classroom. Current teacher education programs at Eastern Kentucky University (EKU) and elsewhere in Kentucky are quite successful at preparing secondary education teachers for the science classroom (KDE, 2000), but requirements in the elementary and middle school teacher education programs at EKU have been more fragmented and contain few credit hours (maximum of 12 credit hours for elementary teacher education without science emphasis) of science content.

An analysis of current science courses offered in the elementary and middle school teacher education programs at EKU demonstrates that no possible combination of 9-12 credit hours of science courses available to education majors will meet all the science content standards required in the K-8 curriculum. Additionally, these courses often enroll 50+ students per section. Under these circumstances, professors are often unable or unwilling to use current best practices in teaching science. For example, few science professors use inquiry-based learning or allow students to work in groups to solve problems. In many cases the classroom's physical layout does not allow students to move desks, so they are not able to easily form into comfortable working groups within the confines of the classroom. Additionally, the science courses either use technology that is sufficiently expensive that it will not be available in the K-8 classroom or they use little technology outside the realm of laboratory equipment. Therefore, current science requirements in the K-8 teacher education programs at Eastern Kentucky University ensure that most future teachers will not be able to meet the content standards nor the technology standards required for quality teaching in the science classroom. With funding from the U.S. Department of Education's PT^3 program, science and education professors at Eastern Kentucky University have designed a series of technology-infused courses that, taken as a package, will ensure that future teachers are exposed to the content and technology standards required for quality teaching in the science classroom. The design process for Earth Science for Teachers will be used to demonstrate the unique qualities of this type of science course and to show the impacts of inquiry-based science courses on teacher content knowledge.

Standards-Based Design

Traditional general education science courses are unsuited to the preparation of good science teachers due to incomplete coverage of K-12 core content in these courses. A survey of science courses and faculty at EKU indicates two reasons for this incomplete coverage: disconnectedness between the objectives of the course/instructor and needs of the pre-service teacher, and unawareness of core content by science content faculty. Of the 23 introductory science courses (100 or 200 level) available to pre-service teachers, 13 of these courses serve as an introductory course toward a major in the discipline or as service courses for other major disciplines. Therefore, the courses are designed to address a particular subset of disciplinary content with the assumption that students will take further courses in the discipline, but pre-service K-8 teachers are not required to take additional courses in the discipline and often do not have adequate flexibility in their schedules to allow for free electives in the sciences. On the other hand, upper level general education courses and introductory general education courses not linked to majors are specifically designed for non-majors, and therefore are not restricted by any content requirements. As a result, these courses are often designed to showcase topics of interest to the instructor with little regard for the needs of pre-service teachers. This subset of courses could be revised to meet the needs of K-8 pre-service teachers, but a survey of science faculty determined that 80% of EKU faculty in the science departments were unaware that specific core content concepts to be taught in the classroom are mandated, and many of those who were aware of the core content standards were only able to demonstrate a nebulous understanding of the core content standards (e.g., students need to know about rocks).

The science courses for teachers created during this project were designed using Kentucky Department of Education guidelines for development of a unit of study (1998). Kentucky's learning goals and academic expectations (KDE, 1995) and core content for assessment (KDE, 1999) relevant to science were identified and partitioned among the four science courses to ensure that all concepts and skills/processes required for K-8 science teachers would be addressed in the package of four courses. Each design team identified essential questions based on the core content on which to focus the learning in the course. The essential questions then guided the design of activities and investigations needed to answer each essential question.

The goal of using standards-based teaching in the courses is to ensure greater quality of science content knowledge in K-8 teachers. To determine the impact of standards-based teaching on the content knowledge of pre-service teachers, the 4^{th}, 8^{th}, and 12^{th} grade TIMSS exam was administered online (www.getsmarter.org) to students in Earth Science for Teachers at the beginning and end of the semester. Each exam is a mixture of six broad science topics: biology, chemistry, earth science, physics, measurement, and scientific inquiry. Students did not receive the exact same set of questions during the pre-testing and post-testing phase, but there is a common and consistent test bank for each grade level. At each testing phase, the following data were collected:

the score of each student, the number of times that each question was answered, and the number of correct and incorrect responses to each question. Questions were sorted based on grade level, science content, and whether the content was covered during the Earth Science for Teachers course. Data were statistically analyzed using the Student's t-test for normally distributed data and the Signed Rank test for non-normally distributed data. The null hypothesis was that there was no change in the proportion of correct responses before and after the course. The alternative hypothesis was that the proportion of correct student responses increased after taking the course. The statistical analyses indicate that there is insufficient evidence that students showed improvement in test performance on material based on grade level or subject matter. The exception is that, using a 90% confidence level, students did show improvement in biology ($p = 0.0117$) and earth science ($p = 0.0977$) when all grade levels are analyzed together. It was determined, however, that an improvement in student test performance occurred after taking the course on questions assessing material covered during the Earth Science for Teachers course ($p = 0.0149$), but there was no improvement on test questions whose content was not covered in the course ($p = 0.2085$). In other words, students learned science core content covered in Earth Science for Teachers by taking the standards-based course.

The most obvious benefit of designing a course based on the core content standards is to improve the students' content knowledge and skills on topics they will be required to teach in the K-8 classroom. However, this method of design also allows the course to address pedagogical issues in the science. The standards-based design encourages the development of inquiry-based activities rather than lecture-driven instruction, encourages collaborative learning environments in the classroom, and encourages interdisciplinary connections as appropriate (KDE, 1998, p. 3).

Inquiry-Based, Collaborative Learning

The content and teaching methods of science faculty in higher education serve as the focal point upon which pre-service teachers base their beliefs, attitudes and behaviors towards teaching science (Tosun, 2000). After completing college-level science courses, pre-service teachers overwhelmingly have negative feelings towards science courses, using words/phrases such as "meaningless", "impossible", and "boring" to describe the courses they completed. Koballa and Crawley (1985) determined that pre-service teachers who dislike science ultimately avoid teaching science, which merely serves to continue the cycle of science phobia. This is partially related to students' self-efficacy. Tosun's study indicated that "a lack of confidence due to low achievement in science courses was evident" (2000, p. 376). Traditional science courses use lecture as the primary teaching method, and science is presented as a series of facts and truths transferred in an authoritarian manner. Students are passive learners and do not become an active part of the scientific discovery process. A course that allows students to enter the learning cycle at the discovery stage and encourages repeated success in the classroom makes a student more confident of his/her own teaching skills (Tosun, 2000). The inquiry-based courses are designed for students to work collaboratively in groups throughout the semester, which encourages students to learn from their peers. Students are also active learners who gain confidence in the process of scientific investigation and in themselves as investigators by using Newton's Rules of Reasoning in Philosophy (Motte & Cajori, 1962, p. 398). Students who completed Physics for Teachers show an improvement in attitude and confidence about teaching science as determined through pre- and post-testing of attitudes. Additionally, student comments on course evaluations indicate that students find the inquiry-based learning non-threatening and relevant to their courses. Finally, students commented that they were able to use many learning styles that helped them to understand the material better. Overall, students feel that they know more science, find science more enjoyable, and feel more confident about teaching science after taking the inquiry-based courses.

Technology Integration

Recent results from the 2002 National Assessment of Education Progress indicate that student performance is improved with the use of technology in the classroom (NCES, 2002). Technology is an integral part of the scientific process, but due to large class size, lack of laboratory time/facilities, and the focus on lecture-driven teaching methods, many pre-service teachers are not exposed to technology integrated into science courses until their science methods course. However, Cronin-Jones and Shaw (1992) demonstrated that beliefs about science teaching held by pre-service teachers were not significantly impacted by their experiences in a science methods course. Therefore, technology integration into science content courses is crucial to preparing pre-service teachers who are capable of using technology appropriately in the K-8 classroom and who understand the importance of technology to scientific investigation and learning. In cases where technology already exists in a science course, it is often used primarily for classroom management, or the technology is significantly advanced compared to that found in the K-8 science classroom. To ensure that pre-service teachers use technology as an integral part of learning and to demonstrate technology available to K-8 teachers, a technology integration plan was developed for the courses in parallel with the content design. This plan requires the designer to identify objectives for the learning activity and to identify how the technology used will help to meet that objective. The technology is used to help answer the essential questions, and is therefore presented as a crucial and integral part of the learning process. Students who completed Earth Science for Teachers during Intersession 2001 indicated on a student survey that they enjoyed the exposure to the software programs during the course (5 out of 12 respondents), and encouraged more technology integration into the course (4 out of 12 respondents).

Pedagogy in Content Courses

Science content knowledge is crucial to the effectiveness of science teaching in the K-8 classroom (NCES, 2002). However, proficient knowledge of science content is not sufficient to ensure that K-8 students will receive a quality science education. Madison County, Kentucky, employs a high number of EKU graduates who successfully completed science courses in their college curriculum, but state assessment scores in science for this county are significantly lower than other subject areas. A survey was sent to all elementary teachers in Madison County requesting feedback regarding potential reasons for the low science scores. In 10 of the 16 responses (62.5%), current in-service teachers replied that science was not being taught effectively (or not being taught at all) because teachers were uncomfortable with the design and implementation of inquiry-based science teaching at this level. For example, one respondent indicates that pre-service teachers "need instruction and materials that will be used and implemented within an elementary classroom, not to be doing excessive papers and reviews". Others indicate that pre-service science instruction "is not focused on classroom instruction techniques or appropriate lesson plan preparation".

The course requirements and structure in the inquiry-based courses rely heavily on the development, use and adaptation of lesson plans from a variety of grade levels. Additionally, student surveys administered at the end of the semester indicate that students find it helpful that the instructors model appropriate activities with appropriate equipment, and that students have opportunities to develop lesson plans for use in their classroom. For example, one student indicated that "the class is an excellent model, and I plan to use everything we did in class in my own classroom". Subsets of these courses have been offered to in-service teachers, and the feedback from in-service teachers, who are most capable of determining the usefulness of the pedagogy presented in the course, was positive. Student surveys were administered in the Earth Science for Teachers course on the last day of class. In-service teachers were asked to answer the following question: "Overall, how would you rate the value of this class?" On a scale of 1-9, with one being significantly below average and 9 being significantly above average, the course received 8.2 ± 0.8. An open response question asked students to "describe any teaching methods which helped you understand the course content". Two-thirds of the students (sample size = 12) indicated that the multiple hands-on, inquiry-based activities were most helpful, and one-third of the students also indicated group discussion of questions was helpful. One student responded, "I already knew the content, but I like the inquiry approach. More teachers will teach this way if <u>they</u> are taught this way." Another student indicates "I think that what I have gained most from this class is the 'how to' teach these concepts to my students. I have always struggled with finding the appropriate labs to teach/reinforce concepts, and this class has given me lots of good ideas along with another approach to teaching science." This evidence suggests that these inquiry-based science courses provide significant support for pedagogical needs of in-service and pre-service teachers.

Conclusion

Quality preparation of future science teachers is the key to improving science education in the K-8 classroom. However, traditional, lecture-based science courses have not been effective at improving content knowledge, improving teacher attitude about science and its importance in the curriculum, infusing technology into the curriculum to enhance learning, nor modeling best pedagogical practices. Preliminary results from research on the design and implementation of standards-based, inquiry-driven courses indicates that the implementation of these courses increased student content knowledge, improved student attitude, integrated technology into the classroom in a relevant and appropriate manner, and provided materials and models for teaching inquiry-based science in the classroom that students found useful and appropriate. Student surveys and statistical analysis of content knowledge assessment support the hypothesis that using inquiry-based, technology-infused science courses to teach pre-service teachers improves student attitude and competence regarding science teaching.

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Learning Virtually – by Design

Patricia J. Donohue
Dakota Science Center
Natureshift Linking Learning to Life Project

From this session, take home our easy step-by-step guide for using online technology to engage your students[1] interest in learning and thinking constructively. The Natureshift (NS) "Exploration Model" makes students think and we are also proving it because students are showing us that it's true. From this session, you will take home our easy step-by-step guide for applying the NS Exploration Model to your classroom, building learning experiences that will help your students pick an individual path to their own learning. Apply this simple technique in your classroom and you will have two guarantees as a result: 1. Students will be engaged and 2. Students will process for you what they learned. You even get a little extra - your students will apply new technology creatively and appropriately in their thinking.

After five years and $5 million building our Exploration Model and testing it with teachers as well as informal educators, our project is beginning to find evidence of learning. We suspect the learning we see in students might prove to be long-term, but that cannot be known until long-term studies assess what we achieved. Nevertheless, we know student thought processes are engaged. We know students show evidence not only of content acquisition but also of higher order thinking. A NS Exploration Project is by nature summative and forces the application of higher order thinking by design. A project engages students because its challenge is authentic to their lives. Learners of any age will pursue their own curiosity about genuine concerns in their world. The result is that a student project will reveal the full extent of what has been learned. The project is constructed from the building blocks of knowledge acquired through the Exploration journey. Because it requires the use of new technologies, students can now teach others what they know and what they have learned more engagingly and more thoroughly. S.A. Barab, et al. in their recent publication "Constructing Virtual Worlds: Tracing the Historical Development of Learner Practices" (Cognition and Instruction, Nov. 2001) confirm the power of local resources and collaborative learning on student constructed knowledge using virtual technologies (pp 47-90).

What is this model and what does it do? It will engage your students' interest. It will guide him or her along a path of self-inquiry in search of new knowledge. Half of that path will take the student on a Web Quest after research information. The other half of that path requires students to quest after this new knowledge in the world around them, at home, at school, in the community. When the student has completed an Exploration, he or she constructs meaning from what was studied, applies it in a self-designed project, and teaches others what was learned. Along this learning path students are given opportunity to employ technology to their tasks. They learn by actively doing. They succeed by having fun. They investigate their lives by satisfying their natural curiosity. You will find it hard yourself to have as much fun again playing with a learning model in your classroom.

On-line Microscopes & Inquiry-based Science Instruction: Improving Technology in Teacher Education

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Abstract: The purpose of this paper is to present a project in which on-line access to a scanning electron microscope (SEM) is used to enhance the science and technology content and pedagogy preparation of preservice teachers. By integrating an on-line SEM into teacher education courses, new teachers emerge from our teacher education program with advanced technological and pedagogical skills to effectively integrate technology into science curricula.

In this paper, we will discuss the incorporation of inquiry-based scanning electron microscope (SEM) activities in three teacher education courses: a science teaching methods course and two instructional technology courses. The use of the on-line SEM and the inquiry-based instructional approaches used in this project are consistent with the National Educational Technology Standards and Science Education Standards. Moreover, this project demonstrates the complexity and benefits of coupling technology and content to significantly enhance science teacher preparation.

At Iowa State University, the integration of the SEM into the education courses occurs at the sophomore, junior and senior levels. At the sophomore level, preservice teachers are first exposed to the SEM in the course Introduction to Instructional Technology. A requirement for all education majors, this course is designed to develop students' basic skills with information technology and to introduce pedagogical considerations in the use of technology in learning. Students learn about the SEM in a large lecture and engage in hands-on activities in the small laboratory setting. Finally, the students explore instructional strategies essential for implementing web-based lessons.

At the junior level, education students who choose to minor in educational computing (approximately 12% of education majors) receive a more in-depth experience with the SEM in the course Using Computers in the Classroom. The sole purpose of this course is to develop students' ability to design and implement technology-based learning environments for K-12 students. In this course, the preservice teachers develop proficiency in using the on-line SEM and design and implement science lessons that effectively incorporate the SEM. In addition, students in this course critique the on-line SEM interface and provide feedback to the developers to refine the webpage.

In the semester prior to student teaching, all elementary education majors (N = 1,000) enroll in the senior level course entitled The Teaching of Science. The purpose of this course is to prepare future teachers to teach science to children in grades K-6. In this course, emphasis is placed on developmental implications, teaching processes, and discovery/inquiry approaches to science instruction. Students in this course develop a working knowledge of the on-line SEM and explore its potential to support K-12 students' science learning. In addition, some of the pre-service teachers have extended their knowledge of the SEM and served as mentors to the inservice teachers wanting to incorporate the SEM in the classroom. In this manner, these students develop proficiency in the operation of the on-line SEM, assist in-service teachers in designing lessons into which SEM activities are appropriate, and experience the classroom use of the on-line SEM with K-12 students.

In each course where the SEM was incorporated, the complexity of technology integration was experienced. To varying degrees contingent on the course and preservice teachers' developmental levels, technology integration beyond teaching about the SEM, was difficult for the students to conceptualize. Although they viewed the SEM as a valuable educational tool, the preservice teachers had difficulty identifying and developing ways to integrate the SEM into the curriculum. In addition, many preservice teachers possessed misconceptions about the capabilities of the SEM. The students often related the SEM to past experiences with light microscopes. As a result, the curriculum integration ideas they developed for the SEM were inappropriate. There were also specific access concerns related to the technology when using the SEM via the internet and in the classroom.

Using the SEM in teacher preparation courses had a number of experiential and pedagogical benefits. The SEM provided an opportunity for future science teachers to use real-world science tools that they can realistically use in their future classrooms. Via the on-line SEM, the preservice teachers engaged in real-world scientific inquiry with experts in the field. Most important, the use of the SEM in the teacher preparation courses created learning environments where preservice teachers were empowered to think critically about science content and authentically engage in the scientific process.

While this project has achieved its goal of enhancing the science and technology content and pedagogy preparation of preservice teachers, it has also generated more questions than it has answered. Integration of the SEM into teacher education courses has provided a vehicle by which we can better understand scientific inquiry-based technology use and it's implications for K-12 classrooms. Further research in this area will be necessary to determine how best to utilize the SEM technology into teacher education courses in order to improve K-12 science education.

Teaching Science to Elementary Teachers: Exploring 'Our Physical World' Through Science and Technology.

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Recent research data provide evidence of a strong focus on the development and fostering of Math and English skills at the elementary level. Unfortunately, other areas of study have not received necessary attention (Goodstein, 2001). At the University of Florida, the School of Teaching and Learning teamed with the College of Liberal Arts and Sciences to address this situation. With the assistance of a PT3 grant, we have designed a course entitled *Our Physical World: Science for Elementary Teachers*. The course discusses basic physical science for elementary teachers, emphasizing applications from everyday life. The scope of the course is similar to many college-level science courses. However, while most courses focus solely on the acquisition of science content knowledge, *Our Physical World* also focuses on the acquisition of pedagogical content knowledge in science (Duggan-Haas, Enfield, & Ashman, 2000). Topics addressed in the course begin with the scientific method and span the entire spectrum of the physical sciences, even discussing Einstein and relativity. The purpose of this course is twofold. First, the course provides tomorrow's teachers with appropriate science content knowledge. Second, the course models appropriate methods of integrating meaningful science learning into the elementary classroom.

In order to attain these goals, *Our Physical World* was designed and created as a web-based learning environment. There were three major reasons for creating this environment. The first reason was accessibility of the information. While initially intended for students of the course, we thought that the information presented, both in the course and on the website, might be useful to other elementary teachers. The second reason was adaptability. With a web-based learning environment, activities and information can easily be updated and modified. The final reason was ease of communication. On the website, individuals will be able to suggest activities that they have found useful, and provide feedback to the creators of the website.

There are four major components to the website: a course information area, a relational database, a search mechanism, and an administrative area. The first component of the course is the "Course Information". This area contains important information for students enrolled in *Our Physical World*. Items such as scheduled events, syllabus information, readings, assignments, and experiments are listed here.

A second major component of the course is the relational database. Upon entering the learning environment, teachers are provided with various activities designed to promote meaningful science learning. This database is part of the course website, but potentially could be accessed by elementary teachers elsewhere. Eventually, the database might be expanded to cover other science areas, such as the biological and chemical sciences. The premise of the database is that elementary teachers can search for activities by choosing various criteria. The search criteria include the following: topic, grade level, keyword, activity type, amount of materials necessary, and Sunshine State Standards (Brogan, 1995). Any, or all, of the search criteria may be used when searching for various activities. The search areas of topic, grade level, and keyword, while general, are useful in narrowing down any search for activities. Activity types will include simulations, laboratory experiments, web-quests, tutorial, classroom demonstrations, and others. One of the more interesting areas of search criteria is the "amount of materials necessary". Upon leaving elementary education programs, students go to different schools, with each of the schools possessing different resources. The "amount of materials necessary" field is broken down into four levels, addressing the varying level of resources. Theses levels are low, medium, high, and computer based. While each of these levels is relative, simply examining a few of the activities for each of the levels would make the criteria for each very clear.

A third component is the search mechanism. This search option was added, after the initial conception of the database, in order to assist Florida teachers relate science instruction to the appropriate standards. This tool allows students to search content by the Sunshine State Standards. Sunshine State Standards as a search criterion will obviously be of most utility to Florida teachers.

The final element of the website is an administrative area. In this area, administrators are able to add, delete, or modify any of the activities or search criteria. Also, there is an area for individuals using the site to suggest activities by completing information about the suggested activity on a form. These activities are then reviewed by the main site administrator, and, based on quality, either added or not.

With further development we hope that this database will prove to be a valuable science instruction resource for teachers everywhere. While only students registered for the course will be able to view the modeling of various activities, it is the opinion of the creators that the resource alone would be extremely useful. As mentioned previously, the database may eventually stand on its own, outside of *Our Physical World*, and may be expanded to contain other areas of the sciences, and possibly videos of the course activities being modeled. With these additions, the goal of improving the instruction of all sciences at the elementary level may be attained.

Resources

Brogan, F. (1995). Sunshine State Standards. http://sunshinestatestandards.org

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Relationships between the use of web resources and student interests in science: Support for technology integration decision-making

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Abstract: This study was designed to investigate the relationships among the use of web resources during middle school science and student science career interests. The results indicated that there were significant predictive relationships between the regular use of web resources and science career interest. Findings suggested that regular use of web resources predicted science career interest scores differently for boys and girls. The regular use of web resources was not predictive of boys' career interests, only predictive of girls' interests in science careers. The use of web resources also had a mediating effect on other characteristics that are generally associated with developing interests in science. Understanding these relationships can help strengthen the processes of designing science education and support decision-making related to securing educational resources that may inspire students to pursue science.

Introduction

The U.S. invests millions of dollars each year on developing and securing new technology-based resources to inspire students to pursue science. To assure these investments are meeting the goals of the educational system it is important to understand the relationships among the types of resources used during science and levels of student interest in science. However, identifying the relationships among resources and interest requires consideration of the complex and multi-leveled environment of the classroom. This study investigated questions about these relationships. Is regularly using web resources during science predictive of middle school students' interest in science? Is the predictive nature of using web resources the same for boys and girls? Is the use of web resources related to differences in science predisposition factors among students?

Career Interest Development

Career development research generally has focused on identifying relationship among family factors such as parents' education and career (Helwig, 1998) and specific school-based career interventions (Hill, et al., 1990) thought to affect children's formation of career aspirations and their eventual participation in adult careers. Gallagher's (1994) work demonstrated that instructional experiences in middle school were predictive of persistence in the study of science in later years. However, no research could be found that investigated the relationships among use of specific educational resources and student science career interests. Interest, an acquired attention or enthusiasm for a particular field, is a learned characteristic and has been shown to be the key factor in making career choices (Hill, et al., 1990, Neimeyer & Metzler, 1987; Vondracek, Lerner, & Schulenberg, 1986; Super, 1984). Emergent interests in a career domain leads to intentions or goals for further activity exposure, which increases the likelihood of subsequent task selection and practice (Lent, Brown, & Hackett, 1994; Flum & Blustein, 2000). Career interest development begins in pre-adolescence, before the fifth grade, when patterns of career aspirations have a tendency to reflect development of the individual's sense of industry (Erikson, 1963; Havighurst, 1964) and interests in line with those careers held by family members or based on direct suggestions from parents or significant family members (Helwig, 1998; Trice, 1992). When children enter into the early stages of adolescence and begin to explore relationships and activities outside the family, including experiences in formal education, they often begin to develop career interests independent of family members. In addition to formal and informal learning experiences, much research has shown that adolescents' development of science career interests is also related to several predisposition factors including the adolescent's 1) perceptions of science – can I see myself as a scientist, 2) perceptions of friends' and teachers' interests in science – are my peers and mentors interested in science, 3) participation in science activities at home and outside of school, 4) use of computer technology in the home, and 5) gender (Boone & Butler Kahle, 1998; Borget & Gilroy, 1994; Gallagher, 1994; Hill et al., 1990; Rocheleau, 1995; Yager & Yager, 1985). Thus, adolescents may be predisposed to pursuing science careers based on relationships with family and friends, formal educational experiences, and career exploration activities during adolescents that support the selection and de-selection of career domains that the individual will eventually choose to pursue (Gottfredson, 1981; Gati 1986). Career interests are therefore learned based on a variety of individual, background, and social factors and further developed as a child proceeds through adolescence. Furthermore, Lent, et al. (1994) suggested that psychological development of career interest is linked to formal academic experiences.

Factors that may affect career interest development

As the Internet becomes more commonly used in classrooms, opportunities to further explore career activities, tools, and people are more available. Recent studies have found that when web resources were introduced into the classroom students interacted in more complex tasks, developed greater technical skills, and used more outside information (Hardin & Ziebarth, 1995; Owston, 1997; Rice, McBride, & John, 1998) than before the Internet was available. Thus, web resources provided vast and easily accessible information and human resources that promoted exploration of and interaction with additional information resources. Adolescent may be able to develop more informed self-perceptions of working within a specific career while interacting with web resources, e.g., participating in exploration and feedback processes. These perceptions may in turn influence science career interest (Blustein et al., 1994). Another factor found to be important in career interest development was gender. Often family experiences (Hanson, 2000) and perceptions of career-related opportunities (Roeser, Eccles, & Sameroff, 2000) strongly influence girls' career choices. Providing rich environments that include web resources, could influence girls choices because science is perceived as a more traditionally 'male' career (Hanson, 2000; Andre, Whigham & Hendrickson, 1999), and thus girls' interests will be more contextually influenced by exposing them to the vastness of science careers and those female role models who excel in science careers. Girls also tend to be more oriented towards social relationships (Swanson, 1997; Gurian, 2001) and may thus be particularly swayed by human contact and collaborative activities generally associated with the collaborative use of web resources in school settings. Since girls tend to work together more collaboratively when using technology and use computers more for learning activities where boys were found to use computers alone and for purposes of gaming, web resources may have more influence on shaping girls career interests (Swanson, 1997).

The Study

A one-time cross-sectional observational method was used to collect data from more than 600 middle school students and their teachers in a diverse group of 23 science classrooms from in three states (Koszalka, 1999). All classrooms were required to have school access to web resources, although there was no requirement that teachers had to use these resources. The middle school students who participated were intact groups from the science classrooms taught by the participating teachers. The dependent variable was Science Career Interest. The science career interest measurement scale was continuous with possible scores ranging from 0 to 36. The higher the score, the more interest the student has in pursuing science-related careers. The student-level independent variable measures were predisposition factors: 1) perception of science, 2) perception of others' interest in science, 3) parental and home factors, 4) interest in science-related activities outside of school, 5) computer technology use in the home, and 6) gender. Teachers were asked to provide information on classroom-level factors, e.g., the types of resources used regularly in the classroom.

Science Career Interest was measured by administering the Investigative (science) career interest summary scale of the Self-Directed Search Career Explorer (SDS), a career-counseling tool for middle school children. As in previous career interest exploratory analyses (Borget & Gilroy, 1994), only the scales for science careers were used so that a relative measure of interest in science careers could be obtained for each participating student. To classify the classroom into resources use types, the teachers were asked to respond to six questions regarding the use of different types of resources during science activities. Responses provided an indication of resource use patterns and were used to classify classrooms into a one of four resources use types.

The career instruments were administered to middle school students at the beginning of a science class at the end of the school year. At the same time, teachers completed the teacher survey, collected the completed surveys and informed consent forms, and sent them to the researchers. Descriptive data were computed using SPSS version 8.0 for Windows. Hierarchical linear models (HLM) were used to examine the associations among classroom-level factors, student-level predisposition factors, and science career interest using two-level hierarchical linear models. This analysis could assess how science career interest differed depending upon classroom variables and on the individual characteristics they brought to the situation, i.e., predisposition factors and gender.

Findings

A total of 677 surveys, from 23 teachers in 9 schools were administered and returned. Fifty-eight surveys were either returned without signed parental consent forms or with incomplete data and were removed from the sample. The remaining 619 surveys were used in the data analysis that included 51% girls (n=304) and 49% boys (n=297). Eighteen students in the sample did not identify their gender. Mean scores were calculated for all boys' and girl's interest in science careers in general and for groups of boys and girls who exhibited each characteristic associated with different levels of predisposition to pursue science. The HLM analyses demonstrated that use of web resources overall was not predictive of boy's science career interests ($t = 2.077$, $p < .061$). Girls' science career interest was predicted by the regular use of web resources ($t = 4.323$, $p < .000$). (See Tab. 1)

Fixed Effects	Estimated Coefficient	Standard Error	T-Ratio	P-Value
BOYS				
Science Career Interest Mean	23.73	0.52	45.060	0.000
Use Web Resources	2.80	1.28	2.077	0.061
Perception of Others slope	0.72	0.27	2.624	0.017
Perception of Others Interests X web slope	-0.42	0.32	-2.298	0.029
Perception of Science slope	0.59	0.09	6.664	0.000
Perception of Science X web slope	0.29	0.10	2.911	0.009
Notes: N = 297, Intercept Reliability Estimate = .700				
GIRLS				
Science Career Interest Mean	23.31	0.46	50.305	0.000
Use Web Resources	4.93	1.14	4.323	0.000
Outside Science Activities slope	0.17	0.24	0.743	0.466
Outside Science Activities X web slope	0.41	0.29	4.700	0.000
Perception of Science slope	0.51	0.09	5.202	0.000
Perception of Science X web slope	0.33	0.12	2.849	0.010
Notes: N = 304, Intercept Reliability Estimate = .651				

Table 1: Student-Level Effects for Boys and Girls

The relationships among science career interests and predisposition factors were different in classrooms where web resources were and were not used regularly. As boys' ($t = 6.664$, $p < .000$) and girls' ($t = 5.202$, $p < .000$) perception of science increased, so did their interest in science careers. For both boys and girls a significant interaction was found between their perception of science and classroom use of the web. The interaction slopes indicated that there were stronger relationships between perceptions of science and science career interest for both boys ($t = 2.911$, $p < .009$) and girls ($t = 2.849$, $p < .010$) when web resources were used in the classroom than when web resources were not used. Perceptions of others' interest in science was positively related to boys' science career interest ($t = 2.624$, $p < .017$). The interaction between perceptions of others' interest in science and use of web resources in science class in boys resulted in a significant negative relationship ($t = -2.298$, $p < 0.020$). The level of interest in science-related outside activities was not significantly related to science career interest for girls ($t = 0.743$, $p < .466$) on its own. However, the interaction between interest in science-related outside activities and use of web resources in science class for girls resulted in a significant positive relationship ($t = 4.700$, $p < 0.000$). Home technology use and parent/home support to pursue science did not have a predictive relationship for science career interest in either boys or girls, nor were the strengths of their relationships different in the students who used web resources, hence they were dropped from the model.

Discussion

Developing interest in specific career domains, such as science, is a consequence of many learning interactions with the people, information, and objects of the practice (Lave and Wenger, 1991). Conceptually, previous research provided indications that working with science practitioners and exploring science information was important to the development of interests in science careers (Vondracek, 1993; Helwig, 1998; Hill et al., 1990). The use of web resources during science can provide adolescents with opportunities for exploring science by providing access to additional social and supportive information. Thus, the significant relationships found support a conceptual hypothesis that increasing the richness of the types of information through web resources during science was related to higher levels of science career interest. In addition, this study provided some interesting findings related to the relationship among the use of web resources and girls interests in science careers. The findings suggested that the use of web resources might have acted as an influencing agent supporting girls developing interests in science because they potentially exposed them to rich examples of science in practice. They may also have provided motivational and interactive experiences as well as another venue for social interaction and learning through collaborative activities with fellow students.

The results of this study also suggested that the relationships between science career interest and predisposition factors were different in classrooms where students regularly used web resources and classrooms where students did not use web resources. For example, all boys' interests in science were predicted based on their perceptions of other's interests in science. If their friends 'liked' science, they were much more likely to 'like' science themselves. When comparing students in classrooms that used web resources and those who did not, the relationship was different. Perceptions of others' interests was not as strong a predictor potentially indicating that sources on information available on the web became more important in informing interest than perceptions' of others in the adolescent's life. Thus, factors such as the use of web resources in classrooms may play a significant mediating role in shaping a student's interests in science careers.

Understanding relationships between the use of web resources and students' science career interests can provide a basis for developing and securing resources that have been empirically shown to be related to higher interest in science careers. If these results hold up in replication studies, there are implications that may support academic decision-making and policy. Given a goal of inspiring students to pursue science careers, policy makers may find this type of research supportive of decisions to allocate financial commitments for enhancing computer equipment, facilitating curriculum development that brings science learning and science communities together, providing teachers with the time and training to integrate web resources into their teaching. These findings shed new light on understanding the complex relationships between the use of resources in the classroom and multiple factors that affect the development of science career interest. Without an understanding of the relationships between the use of resources in the classroom and student science career interest there is a risk that large investments in educational resources will go unmatched in student outcomes. The results of this study demonstrated that the regular use of web resources in middle school science classrooms were predictive of girls' interests, but not boys' interests in science careers. The use of web resources also seemed to have a mediating effect on the relationship among predisposition factors to pursue science and science career interest. Understanding such relationships can inform decision- and policy-making in regard to providing access to, and support of, web technology use in the classroom.

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The Regents Scholars Program - Creating a Statewide Collaboration to Enhance Mathematics and Science Education

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Abstract: The Regents Scholars Program is a unique and distinguished academic experience for in-service teachers. This statewide program draws upon the expertise of university faculty across Ohio to offer professional development that combines mathematics or science content with inquiry-based pedagogy. Teachers will have the opportunity to work with Arts & Science and Education faculty at 13 participating universities in a combination of distance and face-to-face learning experiences. The implementation plan for this project emphasizes faculty development, course development and establishing a collaborative degree structure. The Regents Scholars Program anticipates enrolling students in the fall of 2003.

Introduction

The Regents Scholars Program is a unique and distinguished academic experience for in-service teachers. This statewide program draws upon the expertise of university faculty across Ohio to offer professional development that combines mathematics or science content with inquiry-based pedagogy. Teachers will have the opportunity to work with Arts & Science and Education faculty at 13 participating universities in a combination of distance and face-to-face learning experiences. After completing 35 semester hours and a capstone project, teachers earn a Master's degree in mathematics or science education. The Regents Scholars Program anticipates enrolling students in the fall of 2003.

Two key features of the Regents Scholars Program are quality and the use of technology. By collaborating and sharing resources, participating universities will be able to offer their "best" to create a truly unique educational experience of distinct faculty, coursework and learning experiences. Technology permits the program to extend beyond one campus. E-mail, interactive television and the Internet also allows for learners to interact with counterparts from across the state and to collaborate with college faculty.

Program Development

The implementation plan for this project emphasizes faculty development, course development and establishing a collaborative degree structure. Faculty development strategies include listservs, a web site and online and face-to-face training sessions. Listservs and the web site are used to share information such as useful web sites, training opportunities and meeting minutes. Funds were also allotted for faculty to enroll in web-based mathematics and science education classes as well as course design and facilitation classes.

Course development strategies include faculty stipends, online course standards and establishing a Regents Scholars Content Excellence Seal for courses that meet the standards. Because of the unique challenges created by inquiry-based pedagogy, few online mathematics and science education courses existed in Ohio. Thus, faculty were offered a $3,000 incentive to put an existing course online. Course guidelines were also developed to reflect the National Research Council, National Council of Teachers of Mathematics and Ohio Academic Content Standards. Lastly, to capitalize on existing, outstanding learning opportunities, the Regents Scholars Content Excellence Seal was developed. Courses that are awarded the seal are eligible electives in a student's program of study.

The collaborative degree structure emphasizes home institutions, cohorts, cross registration and face-to-face summer institutes. Students will be assigned to home institutions. The home institution serves as the university of record and enrolls the student, keeps the transcript and awards the degree. Cohorts will also be initiated at the face-to-face summer institutes and maintained through a Regents Scholars Program web site that promotes reflection, collaboration and support.

Participating Universities

Universities participating in the program include Bowling Green State University, Cleveland State University, Kent State University, Miami University, Ohio University, Shawnee State University, The Ohio State University, University of Akron, University of Cincinnati, University of Dayton, The University of Toledo, Wright State University and Youngstown State University. Sponsoring organizations include Ohio Board of Regents, Ohio Learning Network, Ohio Department of Education and Ohio Resource Center.

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Negotiative Concept Mapping

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Abstract: This paper shares the results of an action research project in a science teacher education classroom. The setting is a laptop university and students have access to Inspiration software as well as networking software (ICU) that allows instructors/students for "real time" viewing of individual student group concept mapping exercises.

Most instructors aspire to creating classroom settings that promote higher-order thinking. A considerable amount of work has been done around the creation of so-called constructivist learning environments (Greening, 1998). As an example, problem-based learning has gained popularity not only because problem solving is practised but because the learning is contextualised. Gagne (1985) posits that problem solving elicits two types of learning namely: the learning of a specific "higher-order rule" that allows the student to address similar problems and secondly a set of general problem solving skills or "cognitive strategies". According to Gagne (1985) "cognitive strategies are a special type of intellectual skills used by the learner to regulate the various stages of information processing". Young (1997) links these information processes and cognitive strategies, see (Table 1).

Information Processes	Cognitive Strategies
Attending & Selective Perceiving	Highlighting, Underlining, Outlining, Adjunct Questions
Rehearsal	Paraphrasing, Chunking, Imagery
Encoding	Concept Mapping, Analogies
Retrieval	Mnemonics, Imagery
Executive Control	Metacognitive Strategies

Table 1: Cognitive Strategies Associated With Information Processes

The Power of Graphic Organisers

Of particular relevance to my own action research is the encoding process. Teachers have effectively used webs as graphic organizers in the process of determining student' s prior knowledge. Semantic networking (Fisher, 1990; Jonassen, 1996; Jonassen, Peck & Wilson; 1999) resembles webbing except that all the links between ideas are labelled with a relational phrase. The concept map, as defined by Novak and Gowin (1984) has emerged as a most powerful graphic organizer. In the strictest definition, the concept map extends the semantic networking labelling and has the additional feature of representing concepts in a hierarchal distribution.

Though a variety of webs and maps have been around for some time, it is only in the last decade that software has been developed specifically to create these graphic organisers. Some examples include: SemNet®, Learning Tool®, TextVision®, CMap® and most recently Inspiration®.

A MindTool Approach

With these pieces of software it becomes very easy to map out ideas. Whereas hand-drawing maps in the past could be relatively time-consuming, these facile software approaches open the door to extend the learning through software-enabled constructivist exercises. Computer–generated graphic organisers represent a class of applications that Jonassen (1996) would refer to as "mindtools". "A Mindtool is a way of using a computer application program to engage learners in constructive , higher-order, critical thinking about the subjects they are studying" (Jonassen, 1996, p.iv).

A concept mapping program for instance may be used in three distinctly different teacher–student exercises: (1) the teacher may have students construct a concept map at the onset of a unit in an effort to access prior knowledge, (2) a teacher may engage students in preparing a pre and post concept map (reference) for a unit of study and (3) a teacher may work with the students in an ongoing exercise that gradually builds the map as the unit content emerges.

Action Research in Science Education

For some time I have posed my teacher interns with the task of preparing a concept map for curriculum units they are likely to encounter in their public school teaching. Acadia University has been a laptop institution (Hemming & MacKinnon, 1998) since 1996. This year as part of the network software accessible to all students and professors, Inspiration and ICU became available. Inspiration is a most popular mapping tool (www.inspiration.com) while ICU is a "home-grown" networking tool (a take-off on ICQ). ICU allows the instructor to link with any obliging student on the network and access (and control) their screen. With a classroom digital projector and laptop docking station, this has allowed for an interesting Mindtool approach.

In three independent science education classes of approximately thirty students I led the following exercise. After a short tutorial on Inspiration in the second class meeting, I asked students to construct a concept map of the content we had analysed thus far. On a weekly basis, students would work in groups to update and modify their concept maps. Because I could access their screens at any time and in turn project their screen for the entire class to observe, it became a unique opportunity to unpack their thinking around the hierarchy of concepts and corresponding relational links. In essence as a class we were able to "negotiate the concept map" in real time.

The Impact of Negotiative Concept Mapping

In ten (one-hour) open–ended qualitative interviews following the completion of the course, there were several emergent themes.

Students found the negotiative concept mapping (NCM) to be a great means of reviewing the work from past meetings. Students suggested that the interactive nature of constructing the NCM in real time allowed them to better understand the nuances and complexities of relationships between concepts. In several instances students alluded to defending their choice of conceptual hierarchy and how it helped them to build confidence in the content. Unanimous reference was made to the quality of discussion that NCM promoted in class. At the close of the course students were asked to submit an essay that summarised their growth in the course. Students were astounded at the practical utility of having constructed a concept of the entire course and found this to be invaluable in assimilating their learning in the course. They repeatedly made reference to the ability to see how all aspects of the course were linked from beginning to end and the inherent "sense-making" that this imparted.

All indications are that this "mindtool" approach utilising Inspiration and ICU, shows great promise for classroom instruction. The facile communication allows the professor and teacher intern to interact in a constructive setting in a way that was never before possible.

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Using the Spreadsheets to Enhance the Learning of Science at Foundation Year Chemistry.

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Abstract
At heart, real understanding in science is essentially qualitative yet is often expressed in mathematical relations. Most advanced science students therefore spend a great deal of time and effort doing calculations. These calculations pose two kinds of demands namely-• some of the mathematical models involved are complex and/or • there is a need for repetitive analysis of large amounts of data and both of these can serve to focus students' attention on mechanical mathematics at the expense of their understanding of the underlying scientific principles. These difficulties reduce the level of cognitive 'chunking'. This a serious hindrance to students' learning and the need is for a tool or tools that can be used to raise the level of chunking so that pupils can focus on the underlying scientific concepts. Ideally such a system would be capable of being used by both pupils to model simple systems in which they can express their understanding of the science involved and by their teachers to construct more complex models for the pupils to explore. This paper examines a variety of ways in which one tool, a spreadsheet, has been used to promote learning in an important concept area, that of chemical equilibrium at a University Foundation Year (UNIFY) chemistry and its implications to classroom practice for teacher educators.

Introduction

Spreadsheets have a number of attributes, which make them suitable for use as a computational tool in the school science classroom and laboratory. For example, they can be used in either of two complementary modes. In the first, students use the tool to express their own ideas, usually by testing a *variety of models* (of their own construction) using *fixed data*, while in the second, students explore models which express the thinking of others, usually by feeding *variable data* into a *fixed model*. The latter category commonly involves exploring the accepted scientific models although it also encompasses students exploring expressions of each other's ideas. The differences between these modes of use are similar to the **expressive/exploratory** distinction described by Brosnan (1989). Schibeci (1989) provide further useful discussions of these ways of using spreadsheets models in science learning environment..

The nature of students' difficulties with equilibrium

Chemical equilibrium is a core chemical concept, an understanding of which is essential for most qualitative and quantitative work in chemistry and thus its study forms a central part of advanced chemistry courses. These courses tend to stress the quantitative aspects of the topic - fulfilling the necessity of teaching students to use the appropriate equations. Studying equilibrium therefore involves both difficult and/or repetitive calculations. In their different ways these provide barriers to conceptual understanding. The topic thus provides a good focus for exploring the different kinds of barriers both these types of arithmetical demand pose to conceptual understanding (Stevens, 1991).

Participants and Context

The participants in this study were UNIFY students at the university of the North, South Africa. Sixty (60) potential student participants were selected from 150 UNIFY students according to their willingness to participate in the research. The sixty students were chosen to achieve a balance of gender, science ability and socio economic background. The participants' background is such that they have been exposed to inadequate teaching, lack of laboratory and computer facilities, little attention to skills and lack of exposure. All these resulted in rote learning by the students, lack of interest / negative attitude and very little or no understanding. The UNIFY intervention provides the students an opportunity to access Computer Assisted Learning (CAL). This initiative is on its developmental stage as there is no proper CAL programme in place. As a way of introducing CAL, the spreadsheets have been used in the chemistry lessons to enhance their learning of some chemical concepts, especially that of equilibrium. A questionnaire was used to find out the students' initial conceptions about equilibrium. A set of spreadsheet activities were designed and undertaken with the students in a computer lab during chemistry lessons. Some interviews were conducted during this sessions.

Addressing the Students' Difficulties

One of the main problems that UNIFY students have in coming to a full understanding of chemical equilibrium is that of the ratio of equilibrium concentrations. Students often believe that at equilibrium the composition of the reacting species is equal to, or at least in the ratio of, the balanced chemical equation for the reaction, e.g. that for the reaction, $2HI(g) \Leftrightarrow H_2(g) + I_2(g)$. One solution to this problem is for a teacher to enter data sets of equilibrium concentrations on a worksheet and allow the pupils to write their own equilibrium law expressions and see the consequences. Knowing the balanced chemical equations the students are free to try any analytic relation they choose on one data set until they find one or ones that give constant values. The other problems students have that can be addressed using the spreadsheets are; the effect of changing concentrations, pressure and temperature on equilibrium.

Implications for Teacher Educators

The use of spreadsheets demand more time from the educator to design adequate integrated teaching and learning materials for the students. It helped in the improvement of the classroom teaching and assessment, as it demanded the design of effective alternative assessment tools. It also motivated the students and enhanced their creative and critical thinking skills. The participants' overall performance in chemistry significantly improved compared to those who learned through traditional methods.

Conclusion

The examples briefly described above cover a range of conceptual, arithmetic and programming difficulties and are intended to illustrate some of the variety of ways spreadsheets can be used to address the variety of mathematical problems faced by students of science. The key point is that the computational tool is being used to allow students to see the quantitative consequences of differing qualitative conceptions. The apparently paradoxical conclusion of this is that a computational tool's most important attribute may be the help it gives in changing qualitative understandings. For the purpose of validation of the instruments, the study will be undertaken again next year with large samples of students from similar programmes.

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Anchoring Instruction in a Web-based Adventure Game: How does it work?

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Abstract: How does one capture best practice from the paradigms of situated learning and anchored instruction and combine that with the powerfully engaging multimedia gaming environments that are popular with adolescents? Is it possible to design a game with substantive science content that is intrinsically motivating for middle school students? These types of questions were the driving force behind the creation of a web adventure series, THE RECONSTRUCTORS™.

The web site (http://reconstructors.rice.edu) is part of a project funded by the National Institute on Drug Abuse. The content focus of this effort is the history and biological impact of a class of drugs known as opioids. The benefits and challenges of using this type of approach for teaching sophisticated science concepts to middle school students is described in this paper.

Pedagogical Foundations

The Internet's unique capabilities offer a certain seductive aspect that engages people of all ages. Not all of the Internet's applications could be said to have high educational value. Yet, from our own research on adolescents' media habits and preference, we find that "playing games" is high on the priority list of how they use computers (Miller, Schweingruber& Brandenburg, 2001). On the educational side of the equation, however, the Internet provides support for new instructional approaches, such as cooperative learning with other learners at a distance, demonstrations, online references, powerful simulations, tips, tutorials, and wizards (Carliner, 1998). Our efforts are directed toward blending the excitement of games with compelling science content to "create interesting, realistic contexts that encourage the active construction of knowledge by learners" (CTGV, 1993, p. 52). The work of John Bransford and the Cognition & Technology Group at Vanderbilt (CTGV) pioneered the way for exploiting the power of technology to achieve serious instructional goals. In their interactive videodisc program, Jasper Woodbury Problem Solving Series, mathematical concepts were emphasized (CTGV, 1990).

The pedagogical strategies of situated learning (Brown, Collins and Duguid, 1989) or anchored instruction (CTVG, 1993) can provide the prerequisite framework on which to build multimedia environments that have significant learning outcomes. The task of blending best practice in education with the bells and whistles of multimedia is challenging. Perhaps that is why it is more common to find multimedia, particularly on the web that is rich in technique, but shallow in content. The use of technology for technology's sake rather than wrapping technology around tried and true learning principles is a common pitfall.

Much of what is available on the web is a compendium of information with little structure or scaffolds on which students might build their own knowledge. Some observers have charged that this has led to 'lazy' learning models, "where the student is simply confronted with a vast resource and left unguided" (Weller, 2000, p.9). This type of exploratory learning can sometimes have an effect opposite from that which was intended. It can cause disorientation, difficulty in navigating from point to point, and cognitive overload (Wild et al., 1994). To overcome these challenges, several researchers have proposed the use of narrative as a means of providing structure to multimedia materials (Laurillard, 1998; Laurillard et al., 2000; Plowman, 1998). The use of narrative in combination with multimedia has several advantages:

- It sets a context or situates a problem that is to be solved.
- It grounds the use of text, graphics, animation, voice/music and interactivity with a certain mood or theme.
- It allows the layering of learning objectives so that an array of objectives as described by Bloom's Taxonomy (Bloom, 1956) can be woven into the story or problem.
- It exploits theories of constructivism that suggest narrative is a powerful instructional tool (Bruner, 1996).

Interactive Multimedia Options

The term "interactive multimedia" can mean a wide range of things. One of the first tasks of an instructional designer is to determine who is the audience and what will best reach them. The delivery options range from producing multimedia CD-ROMs or DVDs to interactive web sites that offer animation, video, and audio by a variety of authoring tools. After consideration of multiple alternatives, the decision to use the web with Macromedia's Flash for the delivery of **The Reconstructors**™ was made. The reasons behind this choice were several:

- It eliminates the distribution issues associated with CD-ROMs and DVDs. If one wants to attract an audience in the school, home or other public Internet access environments, then web delivery has a ubiquity that far surpasses the distribution of a disc. The ability to have the site linked from other sites cannot be underestimated;
- Macromedia Flash allows for the expansion of screen size unlike other authoring tools that have a fixed window in which to view the production;
- Flash allows for relatively small files sizes that can be downloaded in segments to address the needs of those with slow bandwidth connections;
- All of the elements of sound, animation, and interactivity that engage learners can be incorporated with Flash; and
- The most significant advantage of Macromedia Flash files is the rapidity with which changes can be made to the site. Based upon feedback from users collected via e-mail, problems can be remedied, or suggestions for improvements can be made almost immediately.

The disadvantages that militate against the use of this authoring and distribution strategy are mainly related to the reliability of schools' connectivity and the use of firewalls that prevent student access. In these instances, we have provided the web site on a CD-ROM for classrooms and this has worked effectively. Another minor disadvantage is the necessity to download the Flash plug-in by those who are not operating with a relatively recent browser.

Weaving Narrative with Learning Objectives

Given that an authoring tool and distribution strategy were determined, the process of moving from learning objectives to final product is non-trivial. Several basic questions had to be addressed:

- What methods, techniques and structuring devices should be used to support students in understanding the science content and demonstrating their knowledge of it?
- What type of narrative is of interest to middle school students?
- What type of story setting and characters should be created that would best match the instructional goals?

- What motivational aids should be included?
- How should the science concepts be presented?

A first obvious step is to articulate what conceptual targets you want encompassed within the adventure game. In our particular endeavor, once we had delineated all the fundamental, as well as the sophisticated neuroscience concepts that were germane to understanding opioids, it became clear that this would have to be an adventure game unfolding in "episodes" or learning chunks. Chunking the concepts also provided an obvious way to support the learner with scaffolds. The interactivity allows one to check at each point whether the learner has acquired the concepts and/or provide feedback. In a gaming environment, these checkpoints, when passed allow the player to "move to the next level." This provides the motivation and captivation typical of adventure games, but adds the educational dimension by focusing on substantive content.

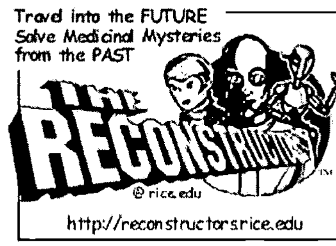


Figure 1. The Reconstructors™ logo features three of the main characters

Adventure games also typically take place in a distinctive story environment or "computer world." In these worlds, the player navigates by clicking or by "picking up " or manipulating objects. Games like Myst, have pioneered this genre. Middle school teachers allowed us time with their students to survey them and follow up with focus groups. The results of surveying over 500 students on their preferences are reported elsewhere (Miller, 2000). We presented our ideas for a setting, a story, and rough sketches of characters to a smaller number of students in focus groups. Through this dialogue the following computer world and corresponding "problem-solving" scenario emerged with the attention to building a narrative that could draw the player through the set of episodes (Figure 2).

THE PROBLEM

It is the year 2252, ten years after the Great Plague that ran through earth's population killing millions and causing the collapse of civilization. Now the earth has entered a new Dark Age, a time when much of the knowledge from the past has been lost.

You are a member of an elite group known as THE RECONSTRUCTORS and you help the People by recovering lost medical knowledge. Your skills are urgently needed because pain-relieving drugs are almost non-existent now. Stories and documents refer to powerful pain-relieving medicine from the past.

Your mission is to reconstruct the knowledge and uncover this medicinal mystery.

All depends on you!

Figure 2. The Reconstructors™ Adventure Mission Statement

A student enters a futuristic world in which he or she assumes the role of a "Reconstructor" charged with re-discovering medical knowledge from the past. The five episodes – Plaguing Problem, Ancient Alarm, Analgesic Anxiety, Mystery of Morpheus, and Alpha and Omega – carry the concepts and narrative forward. Over the course of the episodes, players "solve the problem" while learning about concepts such as neurotransmission, the neurobiology and history underlying drug addiction, pain management, and analgesia.

The actual design process moved to a flow chart of the narrative with interactivity and learning objectives denoted to ensure that the narrative both incorporated the agreed upon concepts and had sufficient interactivity to engage the learner. The creation of storyboards depicting each screen followed. It was this final step that was then turned over to the Flash programmer. An example of a segment of a storyboard follows (See Figure 3).

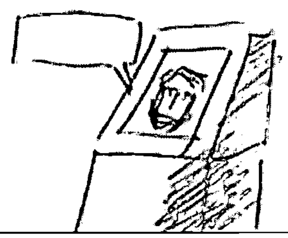
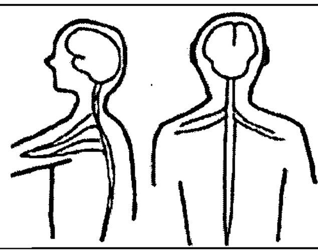
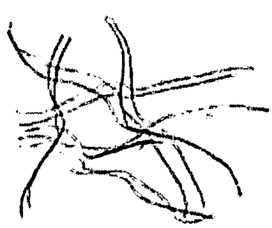
15.		To whoever finds this record, my time is running out. The plague is killing me, and I don't want my data on the nervous system and what each part does to be lost. This system is the key to making smart robots and so much more. Without it, we would not be able to think and move or feel pleasure and pain.
		Interactivity: Button Advance
16.		**Parts of the Nervous System:** Brain Spinal Cord Peripheral Nerves Neurons
		Interactivity: At the top of the screen is the title: Parts of the Nervous System. Underneath this are the 4 parts that are hotlinks. Each time the player clicks on a part of the nervous system, that part lights up in the nervous system diagram (on the left hand side of the screen) and information about it appears on the right hand side of the screen. When the player clicks on neurons it hotlinks to Fred's Nerve2 Neuron sequence
.17.		Neurons: link to Fred's Nerve to Neuron Sequence.
		Interactivity: Button advance

Figure 3. Storyboard Segment from "Mystery of Morpheus"

The comments received from end-users suggest that the web site has drawn the attention of students of all ages to investigate topics that may not normally be tremendous attention grabbers. Yet, crafted within the game environment and built around solid educational strategies, the site has proven efficacious in both gaining screen time and teaching difficult topics. Another paper presents the results of pre and posttest field test results with middle school students. Significant gains were made in specific knowledge concepts for students of all socio-economic status groups and for both genders. (Miller, Schweingruber, Oliver, Mayes and Smith, 2002).

Summary

Bruner's (1996) advocacy of narrative as an effective pedagogical approach in science education coupled with the "problem-solving" characteristics of CTVG early work in multimedia were used to produce a web adventure series with substantive science content within an engaging computer world. This process and the decision points helped to generate an adventure series that has been commended by several educational organizations. To our initial question, can the power of the game environment be harnessed for educational ends; the answer is a definite yes.

The instructional design steps were:

- Determine scope and specific science concepts.
- Devise "problem" or adventure through dialogue with students.
- Create flowchart of web adventure.
- Produce screen-by-screen storyboard.
- Obtain teacher input.
- Program the resulting product.
- Evaluate outcomes.

The success of the initial series has spawned the creation of a second series, MedMyst, which explores the topic of infectious diseases. (See http://medmyst.rice.edu.) The same procedures described in this paper were employed. Again targeted at middle school students, this web adventure may also find its way into classrooms across the world via the Internet.

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Math and Science Education using Spreadsheets and Modeling.

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Abstract: In this article we present examples of a series of spreadsheets designed to support teaching math and science at the junior and high school levels. Each spreadsheet has an accompanying worksheet which guides the student in the exploration of the topic contained in the spreadsheet. These materials were bom as an extension to two parallel projects. One, has the aim of teaching math with technologies. The other, has the purpose of using mathematical based explanations to support the teaching of the sciences (chemistry, biology and physics). To illustrate the whole package of activities, we will also include part of a worksheet corresponding to one of the spreadsheets presented.

Modeling as a learning strategy and Spreadsheet Modeling

There are two different objectives in the classroom connected to the modeling process. One is to learn to construct mathematical models. The other is to take advantage of this activity to learn some of the topics in the science or math curriculum.

A book that gives a wide view of different attempts to use modeling software in education is the one edited by Harvey Mellar and others (Mellar et al, 1994). The theme of this book is well summarized in the first paragraph of the Introduction, "Modeling and Education" by Harvey Mellar and Joan Bliss:

> *"This book is about modeling in education. It is about providing children with computer tools to enable them to create their own worlds, to express their own representations of their world, and also to explore other people's representations. It is about learning with artificial worlds".*

According to these authors, the purpose of modeling in education is to create "artificial worlds" as images of real phenomena to allow the students to reason and learn with them. This group distinguishes between two different types of learning activities associated with modeling, "exploratory" and "expressive". Exploratory activities are ones in which learners explore models provided by someone else, for example a teacher. Expressive activities are ones which learners construct models according to their own ideas.

Our own experience has shown that modeling in the classroom is really a combination of both kinds, since, to begin with, the computer tool already restricts the way a students can design the model. Actually, for the learning to be effective, it is recommended to let the student express their own views but with some guidance through worksheets.

In our early research (Sutherland et al, 1996), we introduced the spreadsheet as an innovation into students' science classroom (physics, chemistry and biology). We designed worksheets which presented the students a particular scientific situation and guided the students to construct the spreadsheet and analyze the results. In the elaboration of the worksheets we follow a didactic approach known by some authors (diSessa, 1993) as "bottom to top". We started the worksheets with very specific cases and gradually move into a more general analysis of the phenomenon.

Due to its structure, the spreadsheet facilitates the modeling process. But probably one of the most important features of constructing a model on a spreadsheet, is that the labeling of parameters, columns and graphs, allows the user to maintain links with the situation being modeled.

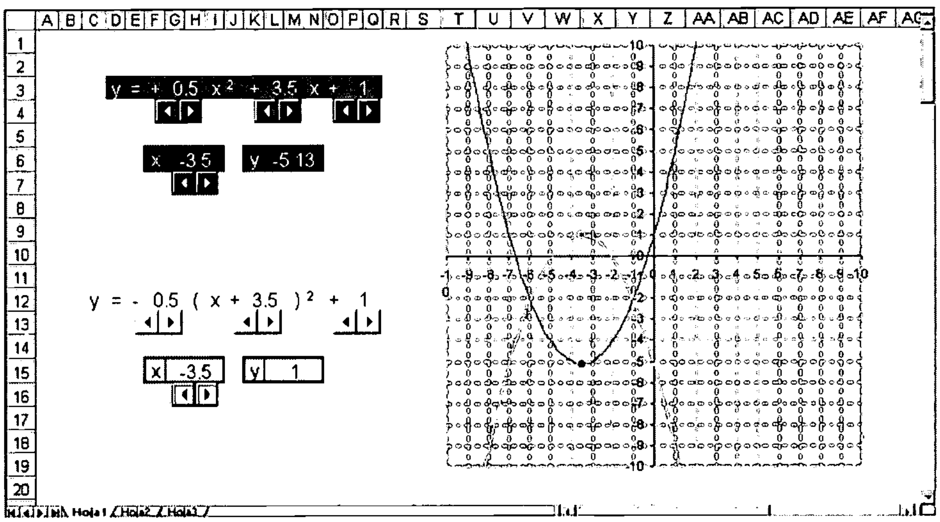
When working in mathematical modeling or in problem solving activities, we move back and forth between the abstract mathematical representation and the physical world. The spreadsheets provide what we can call an "intermediate state". This, in a way, is a link between the abstract and concrete worlds. This artificial world has characteristics of both worlds, so there is no need to go back and forth between them during the analysis and we can stay most of the time in this "in between state".

For the last six years, the Ministry of Education of Mexico has being sponsoring, a national program to teach math and science with technologies at the secondary level (Mochon, 2000 and 2001). Parallel to this educational project, there is an ongoing research project that has as its main purpose to investigate the impact of this technological implementation in students' learning, teaching practices and curricular transformation.

The materials presented in this article were developed as an extension to this educational project. They are both of the expressive and the exploratory type (with the guidance of worksheets). The first of the next two sections shows some of the spreadsheets for the math class. The second shows some of the spreadsheets for use in the science classes (chemistry, biology and physics) which stress the math content of the topic to achieve a deeper understanding of the scientific concepts.
Part of the research that was conducted during these years was to pilot the activities in the classrooms and to improve them accordingly. The spreadsheets presented in this paper are the latest versions of the activities.

Teaching math with spreadsheets

A deeper conceptual understanding of math requires the coordination of several representations like the symbolic, the graphic and the numeric and their connection to real contexts to provide meaning. This can be accomplished using the spreadsheet as a tool with its several representations and embedding the topics (as much as possible) in real situations (mathematical modeling approach). The materials presented in this section have these characteristics.
For example, the following spreadsheet shows an exploratory activity on the topic of quadratic equations (the graphs moves according to the values of the constants in the equations which can be changed by controls).



Notice that there are two different forms of the quadratic equation, one in red and one in yellow. The use of this spreadsheet is assisted by the following two worksheets.

Activity :
Exploring graphically quadratic functions (1).
(uses Excel file "QuadraticExplor")

In this activity you will explore graphically quadratic functions in two of their standard algebraic forms, finding the effect of each coefficient.
Getting acquainted with the spreadsheet: Open the spreadsheet "QuadraticExplor"
On the left side of the screen you will see two quadratic equations (one in red and one in yellow) written in different forms. Each of the three constants in them has a control so you can change the equations as you wish. Do this and observe how the graphs on the right move accordingly.
Below each equation you can find represented a point satisfying that equation. You can change their x value with the controls associated with them. Do this and observe how the corresponding point moves along the graph.
Project #1:
Investigate the family of parabolas:

$$y = x^2 + c$$

Describe the family: ________________ ...
What does the constant c represents? ________________ ...

Project #2:
Investigate the family of parabolas:

$$y = a\,x^2$$

Describe the family: ________________ ...
What is the difference between the parabolas with "a" positive and negative? ________________ ...

Project #3:
Investigate the family of parabolas:

$$y = (x + r)^2$$

Is there a change of shape or only a change in position? ________________ ...
Describe the family: ________________ ...
What exactly does the value of r represent? ________________ ...

Project #4:
For the second equation, given in the form: $y = a\,(x + r)^2 + s$ *, find out the effect on the graph when each of its constants is changed.*

Project #5:
For the first equation, given in the form: $y = a\,x^2 + b\,x + c$ *, find out the effect on the graph when each of its coefficients is changed.*

Exploring graphically quadratic functions (2).
(uses Excel file "QuadraticExplor")

In this activity you will explore graphically quadratic functions considering the three cases that might occur related to their zeros and showing the equivalence between two of their standard algebraic forms.
Getting acquainted with the spreadsheet: Open the spreadsheet "QuadraticExplor"
(see previous activity)

Project #6:
Write the first equation on the screen as: $y = x^2 - 6\,x + 5$
Using its graphical representation, find the location of the zeros of the above function: $x =$ ____ *and* $x =$ ____
Change the equation to: $y = x^2 - 6\,x + 8$. *Now the zeros are:* $x =$ ____ *and* $x =$ ____
Change the equation to: $y = x^2 - 6\,x + 9$. *Now the only zero is:* $x =$ ____
Finally change the equation to: $y = x^2 - 6\,x + 10$. *What happened with the zeros of this function?* ______ ...
Analyze now the family of parabolas: $y = x^2 + 4\,x + c$ *to find out for what values of c there are two zeros, one zero or no zeros. State your findings here:* ________________ ...
Give some general conclusions about the zeros of quadratic functions: ________________ ...

Project #7:
Write the first equation on the screen as:

$$y = 2\,x^2 + 4\,x + 1$$

Change now the constants of the second equation until you make its graph coincide with the first one. Write below the equation you found:

$y =$ ________________

Verify algebraically below that these two equations are equivalent.
Now write the second equation as:

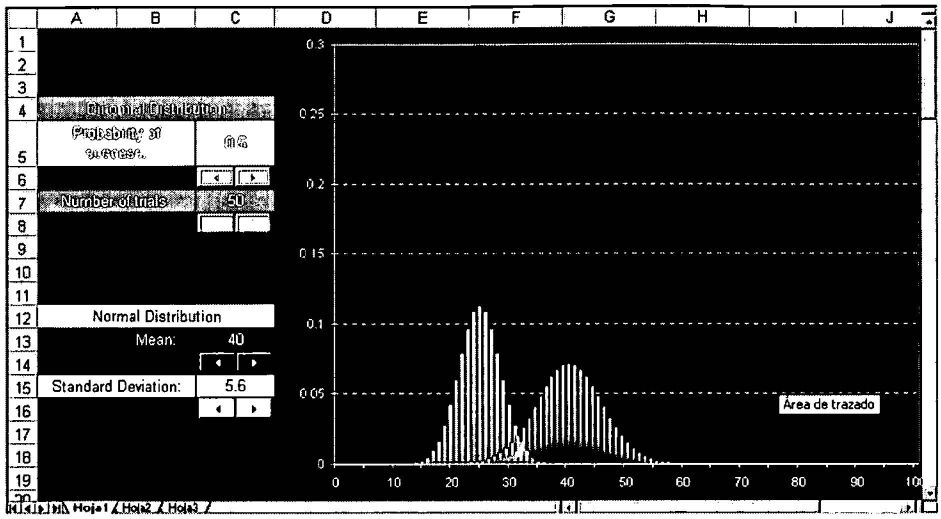
$$y = (x - 3)^2 - 2$$

Change now the constants of the first equation until you make its graph coincide with the second one. Write below the equation you found:

$y =$ ________________

Verify algebraically below that these two equations are equivalent.

The spreadsheets developed in this fashion cover a wide range of topics within the subjects of arithmetic, algebra, geometry, probability and statistics and higher math like calculus and differential equations. Their main objective is to use the graphical representation as a center piece since visualization helps the student better understand the math concepts.
To give one more example of these exploratory activities in mathematics, the following spreadsheet contains the graphic representation of the binomial and normal distributions. Each of these distributions has two parameters that can be changed with controls, seeing the effect immediately in the graphs. This graphical representation is very useful to compare the two distributions and determine in what circumstances the normal distribution can be a "good" approximation of the binomial distribution.



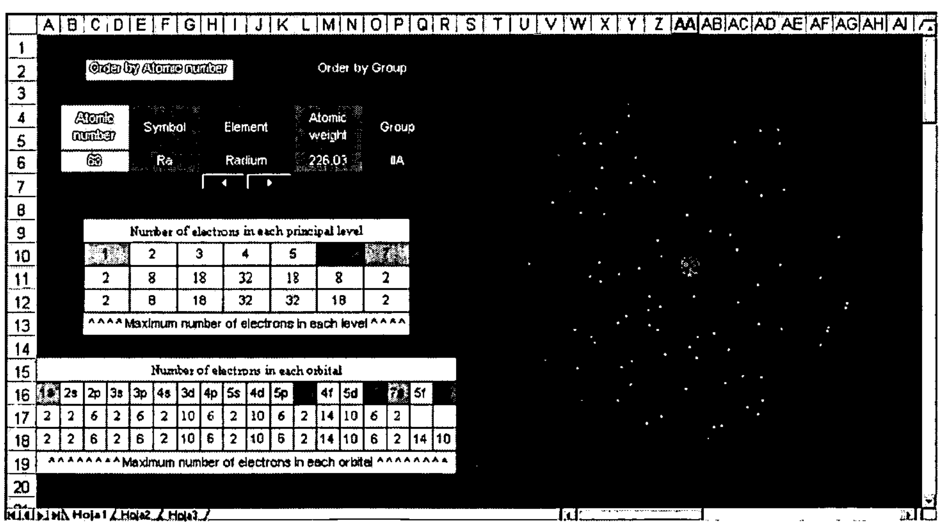
Teaching science with spreadsheets

We can predict natural phenomena because it follows some ordered behavior. Behind this order, we find a few principles that can be formulated mathematically. A deeper understanding of science requires the use of these principles as mental tools.

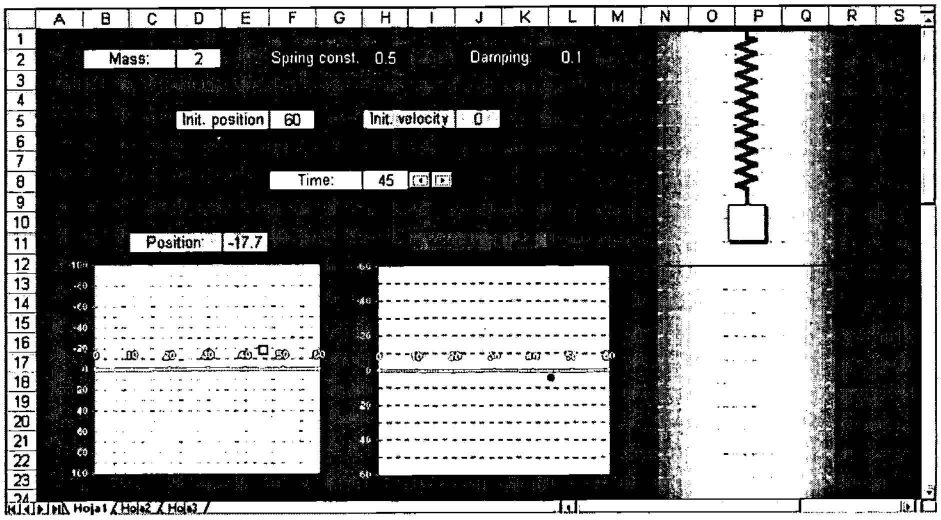
Thus, the materials presented in this section are based on the idea that the students can achieve a better understanding of some scientific phenomena if they are imbedded in proper mathematical formulations that will give them a more precise structure and the possibility of quantification. The activities in here have the aim of complementing the normal presentation of subjects done by the science teachers in their classrooms.

The applications of this spreadsheet are almost endless and depend on the particular objective of the teacher (some worksheets are already developed to use with this spreadsheet).

The next spreadsheet shows the electronic structure of atoms. In the right side of it, the element can be chosen with a control (the elements can be ordered by atomic number or by groups). The program gives all the information about the number of electrons in each orbital. In the right side of the screen appears a model of the atoms with each of the electrons represented in a color corresponding to the level it belongs. Again, the visual image is very helpful (each electron moves randomly around its orbit when pressing the F9 key).



Finally, the last spreadsheet shown below is a simulation of the system spring+mass. The user can fix the values of the mass, the spring constant and the damping constant. Also, he can decide on the initial position and velocity of the mass. With the control associated with the time, the simulation can be moved forward and the graphs will show the position and velocity of the spring (the spring on the right moves up and down accordingly).



Conclusions

As we could see from the examples given in this article, the spreadsheet is a very versatile tool to design all kind of exploratory activities in math and science. It has the important characteristic that we can combine together the numerical and graphical representations of the situation being presented. In addition, the controls in it give a dynamic component which is very effective for visualization purposes (obviously, this feature can not be shown in the static pictures presented in this paper).

An added extra feature of the spreadsheet is that through all the labels in tables and graphs, the spreadsheet keeps a close contact with the phenomenon being modeled or the problem being solved. This is very important when the spreadsheet is used for educational purposes.

Another crucial idea hidden in the modeling of the spreadsheet is that recursive relationships are the main mode to express formulas in it. This suggests that we should bring into the classrooms of math and science, more consistently, this type of recursive math.

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A Gathering of BUGS

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Abstract: The purpose of this video will be the presentation of first year, after-school activities of participants in the Bringing Up Girls in Science (BUGS) grant project. The video will observe the 4th & 5th grade participants in the science lab, interview the participants and interview the lab instructors.

Science and Mathematics Teachers Perceptions' of Graphing Calculators and Change

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Abstract: The purpose of this study was to determine mathematics and science teachers' initial perceptions of change prior to their participation in a year-long professional development program that emphasized integration of the math and science utilizing graphing calculators. The results indicate that as a group, the teachers (1) exhibited high information stage concerns and collaboration stage concerns; and (2) are more aware of the graphing calculator and its potential than previous groups. Mathematics teachers were more familiar with utilizing graphing calculators while science teachers were more familiar with utilizing computers. Mathematics teachers reported higher technological proficiency, but their stage concerns were not statistically different from the science teachers.

Mathematics and science educators include the use of technology as a common goal in their most recently developed standards. The National Council of Teachers of Mathematics *Principles and Standards for School Mathematics* (NCTM, 2000) suggests a framework for the types of technology-based activities and content that should be taught. Similarly, the National Research Council's *National Science Education Standards* include suggestions for science education reform in technology-based content and professional development (NRC, 1996). Further, both documents point toward significant increase in the integration of math and science. Reading between-the-lines, technology is encouraged as a tool that can facilitate such integration.

Graphing calculators show promise for integrating mathematics and science. There is a growing body of recent research into the use of graphing calculators in the teaching of algebra (Beckman, Senk, & Thompson, 1999; Dunham & Dick, 1994; Embse & Yoder, 1998; Milou, 1999;); in both chemistry and physics (Adie, 1998; Roser & McCluskey, 1999; Taylor, 1995); and even the integration mathematics and science (Tharp et. al.).

The State of Texas has developed the Texas Knowledge and Skills (TEKS) (http://www.tea.state.tx.us/teks/). The TEKS clearly extend the national reform documents by specifically indicating the use of graphing calculators in algebra:

> Students use a variety of representations (concrete, numerical, algorithmic, graphical), tools, and technology, including, but not limited to, powerful and accessible hand-held calculators and computers with graphing capabilities and model mathematical situations to solve meaningful problems (§111.32. Algebra I (One Credit) #5).

Beyond the explicit statement that graphing calculators be used in the teaching and learning of mathematics, the new Texas Assessment of Knowledge and Skills (TAKS) (http://www.tea.state.tx.us/student.assessment/taks/index.html) **requires** the use of graphing calculators on the state-mandated tests at the ninth, tenth, and eleventh grades for math and at the eleventh grade for science.

Theoretical Framework

The implementation of technology will require change in the classroom. One model that has been utilized to inform the decision-making process when innovations are introduced is the Concerns-Based Adoption Model (CBAM). CBAM states that successful implementation of an innovation is a process not an event (Hall & Hord, 1987; Fullan, 1991; Friel & Gann, 1993), developmental in nature (Hall & Hord, 1987), and a highly personal experience for each teacher (Hall & Hord, 1987). Hall, George & Rutherford (1986) define concerns as the feelings, thoughts, and reactions that individuals have about an innovation or a new program that touches their lives. To measure these concerns, Hall, Wallace & Dossett (1973) developed the Stages of Concern Questionnaire (SoCQ). Initial research on the instrument construction verified the existence of seven stages in the concerns process: awareness, informational, personal, management, collaboration, and refocusing, with internal reliability for individual scales ranging from r=0.64 to r=0.83 (Hall, George & Rutherford, 1986).

Participants

The participants in this study are high school math and science teachers from a single large urban school district in Texas participating in a year-long professional development program that is ultimately aimed at improving math and science achievement. Within the professional development program, the teachers are divided into two sub-groups. The two subgroups are Algebra I (ALG I) with Integrated Physics and Chemistry (IPC) and Algebra II (ALG II) with Chemistry I (CHEM). The teachers are paired because the vast majority of students who are enrolled in ALG I will also be enrolled in IPC and because there is significant overlap in the knowledge and skills that are taught in each course. There is less overlap with students for the ALG II and CHEM group, but curricular overlap is strong enough to warrant the pairing. The teachers are recruited through their building principal and science department chairs and must participate as pairs, one from math and one from science.

The focus of the professional development is on increased communication and collaboration between math and science teachers within the district and specifically in individual schools, with a heavy emphasis on technology. Graphing calculators (TI-83s), Calculator-Based Laboratories (CBLs), and Calculator-Based Rangers (CBRs) with multiple probes were provided to all teachers at the beginning of the program to be used in all subsequent workshops. Each teacher will ultimately receive a minimum of 125 hours of professional development that culminates in a two-week summer institute. Upon the completion of the 125 hours, each teacher will receive a set of ten calculators, CBLs, and CBRs, an overhead panel for display purposes, and up to four additional probes for use in their classrooms.

Methods

Research questions

1. Are there significant differences between the holistic stage concerns profiles for mathematics and science teachers?
2. Are there significant differences between the stage score profiles for mathematics and science teachers?
3. Do the demographic profiles differ for mathematics and science teachers?

Data was collected from a total of forty-three secondary mathematics and science teachers during their respective introductory sessions in September 2001. There were 21 science teachers and 22 mathematics teachers.

All participants were administered the Stages of Concern Questionnaire (SoCQ) on the first day of the in-service. The SoCQ is a thirty-five item Likert-scale instrument that contains seven levels of responses. The responses range from 0 = irrelevant to me, 1 = not true to me now, to 7 = very true to me now. A demographic survey also was administered at this time. The survey collected two types of information: background and technology-using history. Background information collected included gender, years teaching, highest degree earned and age. Technology-using information collected included self-rating of the ability to integrate graphing calculators and computers in the classroom, in-service training received, and number of years integrating a graphing calculator and computer in the classroom.

Mean stage scores and total concerns score were calculated for mathematics and science teachers. To determine overall concerns levels, two analyses were performed. First, mean stage scores were converted to percentile ranks based on the norms presented by Hall, George & Rutherford (1986). Second, a peak stage score analysis was calculated for each group. Peak stage scores are defined as the stage at which an individual has his or her highest percentile rank score on the seven concern stages (Hall, George & Rutherford, 1986). Finally, analyses of variance (ANOVAs) were performed on mean stage scores and total concerns score to determine subgroup differences. Since there are seven stages of concern, the significant p-level for mean stage score ANOVAs was $p=0.007$ ($p=0.05/7$). Total score ANOVAs used a significant p-level of $p=0.05$.

Results

Mathematics teachers had the highest percentile concerns at the awareness and information stages and their lowest percentile concerns at the management and consequence stages (Awareness=81, Information=80, Personal=76, Management=47, Consequence=48, Collaboration=68, and Refocusing=42). Science teachers had the highest percentile concerns at the information stage and their lowest percentile concerns at the management and refocusing stages (Awareness=84, Information=91, Personal=85, Management=56, Consequence=63, Collaboration=80, and Refocusing=57). Overall, the percentile scores demonstrate that both groups are very aware of graphing calculators and their uses and want to learn more about how this technology impacts their classroom. The profile also demonstrates that the groups were users of the technology in the classroom but still desiring information on how to best integrate the technology to impact student achievement.

No significant differences ($p<0.007$) were found between the two groups of teachers. Thus, while percentile scores varied slightly as to highest and lowest percentile concerns, all participants entered the in-service with similar expectations.

Demographic analysis found that (1) participants were predominantly female (>60% for each group), (2) most chemistry teachers had a masters degree or higher while most mathematics teachers had only a bachelor's degree, (3) years of teaching experience was related to course taught (more years taught the higher the level class), (4) most mathematics teachers had never integrated computers in instruction while most science teachers had integrated computers in their instruction, (5) almost all mathematics teachers had integrated graphing calculators in the classroom while science teachers had used graphing calculators in instruction, and (6) science teachers self-rated themselves as novice users of graphing calculator and intermediate (almost experts) at using computers in the classroom while mathematics teacher considered themselves novices at integrating computers in the classroom and intermediate (almost experts) at using graphing calculators in the classroom.

Summary

Both groups entered this in-service very aware of the technology being discussed in the in-service and wanting to learn more about applications of the technology in the classroom (high information stage concerns). Needs focused primarily in the areas of how will this curricular change impact me and my teaching (high personal stage concerns) and how can I work with others to help bring about this curricular transition (collaboration stage). This early awareness of graphing calculators and interest in the integration process is atypical for those entering previous math, science, and technology professional development programs (Chamblee, 1996; Chamblee & Slough (in press); Slough 1998;). This warrants further investigation.

Demographical data present distinctly different groups. This fact agrees with current research in this area (Chamblee, 1996; Chamblee & Slough (in press); Slough 1998;). Science teachers were more familiar with integrating computer applications in the classroom while mathematics teachers were more familiar with integrating graphing technology in the classroom. This finding is consistent with emphases in both disciplines. Also, math teachers rated their technical proficiency high with regard to the graphing calculator and the science teachers rated thems elves as novices. Yet, there was no statistically significant difference between the groups mean stage concerns. At first, this may appear to be problematic with regard to either the self-reporting or the CBAM model. When, in fact, mere technological proficiency does not make one immune to the same stages of concern. This warrants further investigation.

Similar research questions were utilized to analyze the differences between the ALG I, ALG II, IPC, and CHEM teachers who participated in the professional development program. Due to the limited space, the results are discussed in a separate paper (Chamblee and Slough (in press B)).

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Integrating Remote Scientific Instrumentation in the Curriculum to Support Inquiry: Case Studies in K-12 and Teacher Education

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Abstract: This short paper describes our ongoing plans to gain in-depth understanding of how teachers and teacher educators are integrating remote scientific instrumentation technology to facilitate inquiry in classrooms by participating in the Bugscope project.

Introduction

As K-12 schools and colleges of education respond to efforts to reform science, mathematics, and technology education, changes are occurring in learning, teaching, and research activities in classrooms (e.g., National Commission on Mathematics and Science Teaching, 2000). Bugscope[1] is an example of such changes. Bugscope allows students, teachers, and teacher educators to study insects and other arthropods through remote access and control of an environmental scanning electron microscope (ESEM). The ESEM is an advanced electron microscope that allows high resolution examination of specimens in their natural states; for example, wet, oily, dirty, non-conductive samples. To participate, teachers and teacher educators submit an online application. Included in their application is a brief proposal where they describe specific classroom plans to use Bugscope. Classrooms mail in insect specimens in advance, and these are prepared and inserted into the microscope. Then, using a World Wide Web (web) browser from their classroom computers, students, teachers, and teacher educators remotely operate the microscope to examine their specimens. Each classroom has opportunities to participate in Bugscope any number of times, and there is no cost for classrooms to participate. A goal of Bugscope is to provide sustainable remote microscope access to K-12 and teacher education classrooms nationwide at a rate of 50 classrooms per year.

Background

Although remote instrumentation is today an exotic and expensive technology, it is becoming part of daily practice in science. This suggests two things (Bruce et al., 1997). First, students, teachers, and teacher educators need to learn more about it because this kind access and control is becoming an integral part of doing science. Second, it is likely to become much more commonplace and less costly in future. The particular instruments and scientific domains may differ, but understanding of the principles underlying this mode of learning through projects like Bugscope is generalizable. Despite the importance of remote instrumentation, few projects have used it for K-12 and teacher education instruction. Two examples are mentioned here. One project is Chickscope[2], which allowed students and teachers from ten classrooms ranging from kindergarten to high school, including an after-school science club and a home school, to study the 21-day chicken embryo development using a remotely controlled magnetic resonance imaging instrument. Another project is MicroObservatory[3], which allows high school students and teachers to control a network of five automated telescopes over the Internet. However, such projects are not applicable across K-12 and in

[1] http://bugscope.beckman.uiuc.edu
[2] http://chickscope.beckman.uiuc.edu
[3] http://mo-www.harvard.edu/MicroObservatory

teacher education classrooms. Also, rarely do such projects allow sustainable, real-time remote access and control capabilities to classrooms across the nation, as does Bugscope.

Challenges of Inquiry-based Learning and Teaching

Recent reports concur that inquiry-based projects successfully facilitate learning. One report has suggested that inquiry-based instruction "allows students to engage in practices of scientists and to construct their own scientific knowledge through investigation rather than memorization" (Linn et al., 2000, p. 2). Another has called for an emphasis on inquiry in teaching and learning across K-12 (National Research Council, 2000). Such reports highlight importance of improving teacher preparation programs through use of information technology. However, getting teachers and teacher educators interested and familiar with inquiry and providing support for them, can be challenging (Thakkar et al., 2001).

Since March 1999, more than 60 classroom sessions in more than 25 US states have participated in the Bugscope project. A report documented that Bugscope serves the purpose of stimulating an interest in the scientific research enterprise among students and teachers across the nation (Thakkar et al., 2000). Yet additional challenges remain. For instance, how does Bugscope contribute to the growth of teachers and teacher educators in understanding the possibilities of remote scientific instrumentation for learning, teaching, and research? How does remote scientific instrumentation technology support student, teacher, and teacher educator collaborations and expand participation in science (especially for underrepresented groups). In general, how do we build a community for inquiry learning?

In order to address such challenges, we are collaborating with Bugscope participants, such as Korb and Lee (co-authors), to develop case studies across K-12 and teacher education classrooms. We plan to use a variety of data (such as classroom proposals, teacher surveys, image acquisitions, session logs, and electronic communications). For instance, Korb wrote in the proposal to use Bugscope in her secondary and elementary science methods course: "*I am interested in modeling the use of technology to these future educators. ... I also feel that having some control over the process of inquiry and discovery when using the Internet is extremely valuable for young students to construct their own knowledge. ... How exciting to be able to choose a specimen, send it to be processed for EM imaging and then explore particular driving questions. ... I will use the process and the final images to show preservice teachers how to further investigate insect and animal life cycles, anatomy, animal diversity and contribution to ecosystems.*"

These collaborations will help to provide a deeper understanding of the impact of remote scientific instrumentation in learning and teaching. Additionally, it will provide an understanding of how this technology is shaped by different classrooms in different ways.

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Measuring and Identifying Trees with the Help of Technology

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Abstract

Digital cameras, spreadsheets, and selected websites enable teachers of elementary and middle school students to "take only pictures, leave only footprints" as they tackle the problem of measuring and identifying trees. In the task described in this paper, teachers experience the integration of the national science, mathematics, and technology standards. They develop a unit of measurement, then measure indirectly, using informal notions of similar triangles. They hone observation and classification skills using an online dichotomous key.

An important focus of our work in teacher education is the authentic use of technology in learning the content and processes of science and mathematics. Tasks that support elementary and middle school preservice and inservice teachers in their development of content and pedagogical knowledge while making appropriate use of technology are not readily available. A team of five individuals—two science educators, a mathematics educator, a graduate student, and a public school classroom teacher—collaborated to develop a task entitled "Measuring and Identifying Trees with the Help of Technology." This task is available at http://msed.byu.edu/pt3/tree.html. We believe it contributes to the following goals for the use of technology in teacher education.

1. Supporting teachers as they learn important science and mathematics concepts and processes (e.g., observation and classification skills; development of a consistent unit of measurement; and use of ratio, proportion, and similar triangles in indirect measurement).

2. Modeling the authentic use of technology in a learning task. For us, authentic use of technology means that the task is much richer for the learner than it would be without the use of technology.

This task is organized as follows:

1. Establish the need for learning to measure the height of a tree or another tall object through indirect measurement.

2. Develop the concept of *pace* as a nonstandard unit of measurement; then, using a spreadsheet and finding the mean for paces of individuals within the group, develop the length of a consistent pace for that group.

3. Applying informally the concepts of ratio, proportion, and similar triangles, measure the height of a tree using a stick as a side of the triangle and the length of a consistent pace as the measure of length.

4. Observe characteristics of the tree in addition to its height (bark, leaves, twigs, seedpods, coloration, etc.); gather data through field notes and use of the digital camera (no collection of artifacts permissible except through virtual means).

5. Using field notes and photographs, consult a dichotomous key on the Intemet to determine the possible identity of the tree. The following websites should prove helpful:

   http://www.cnr.vt.edu/dendro/dendrology/syllabus/key/key1.htm —This site helps you identify trees using the characteristics of leaves.

   http://www.cnr.vt.edu/dendro/dendrology/syllabus/twigkey/key1.htm —This site helps you identify trees using the characteristics of twigs.

   http://www.enature.com/guides/select_trees.asp —This site will help you identify a tree by leaf type or other attributes, or you can enter a tree name for information about the tree.

   http://www.noble.org/imagegallery/woodies.html —This site provides images and information on selected trees and shrubs.

Ideally, the first stages of this task should occur in an outdoor environment, especially the measurement of the heights of trees. In the absence of trees with foliage, however, the experience of measuring trees can be replicated through the projection of photographs of selected trees on overhead screens around the room.

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